Moisture Control Using Intelligent Single Well Electro-osmotic Dewatering Systems

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US Army Corps of Engineers
BUILDING STRONG®

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Outline

- Technical Objective
- Background
- Principles of EO
- Test Site
- Technical Approach
- Laboratory Testing
- Metrics Plan
- Summary

Technical Objective

The objective of this project is to demonstrate and evaluate the use of a Intelligent Single Well Electro-osmotic Dewatering Systems in controlling of water seepage through porous materials such as reinforced concrete

The broad end product of this work is a performance envelope for the use of alternative waterproofing technologies such as EOP for both new and existing construction.

Background

Needs

- Method to lower interior relative humidity in below-grade structures
  - ► Reduce corrosion of mechanical equipment
  - ► Eliminate the harmful mold and bacteria
- Method to prevent water seepage into below-grade structures
  - ► More cost-effective than conventional
  - ► Long system lifetime

Background

Needs

- Present waterproofing methods
  - Apply waterproofing material to exterior
    - excavation required
    - very expensive
    - very disruptive
    - short lifetime
  - Install drains inside
    - sump and pump required
    - large trench must be dug for pipe
    - still have high interior humidity

Background

Problem

Water seepage into buildings causes structural decay and equipment deterioration

Standing water at EOP demonstration site, Building 3265, Fort Jackson, South Carolina, prior to EOP system installation

Background

Problem

Water intrusion into buildings causes poor indoor air quality

Water intrusion at Quarters 1, WES. Note dehumidifier in background.

Background

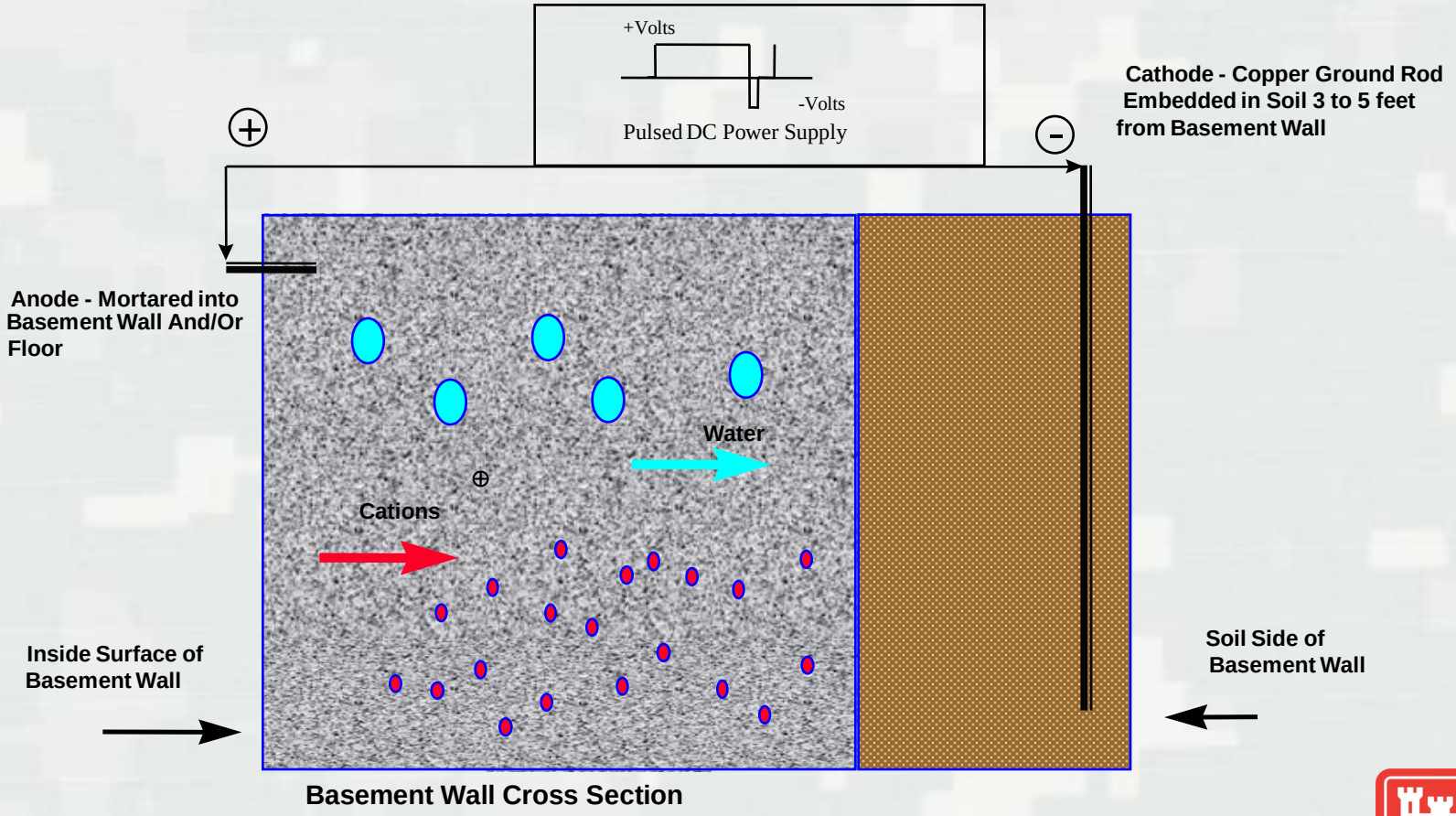
Problem

Water intrusion into buildings causes poor indoor air quality

Severe mold and rising damp in Building 21, Fort McNair

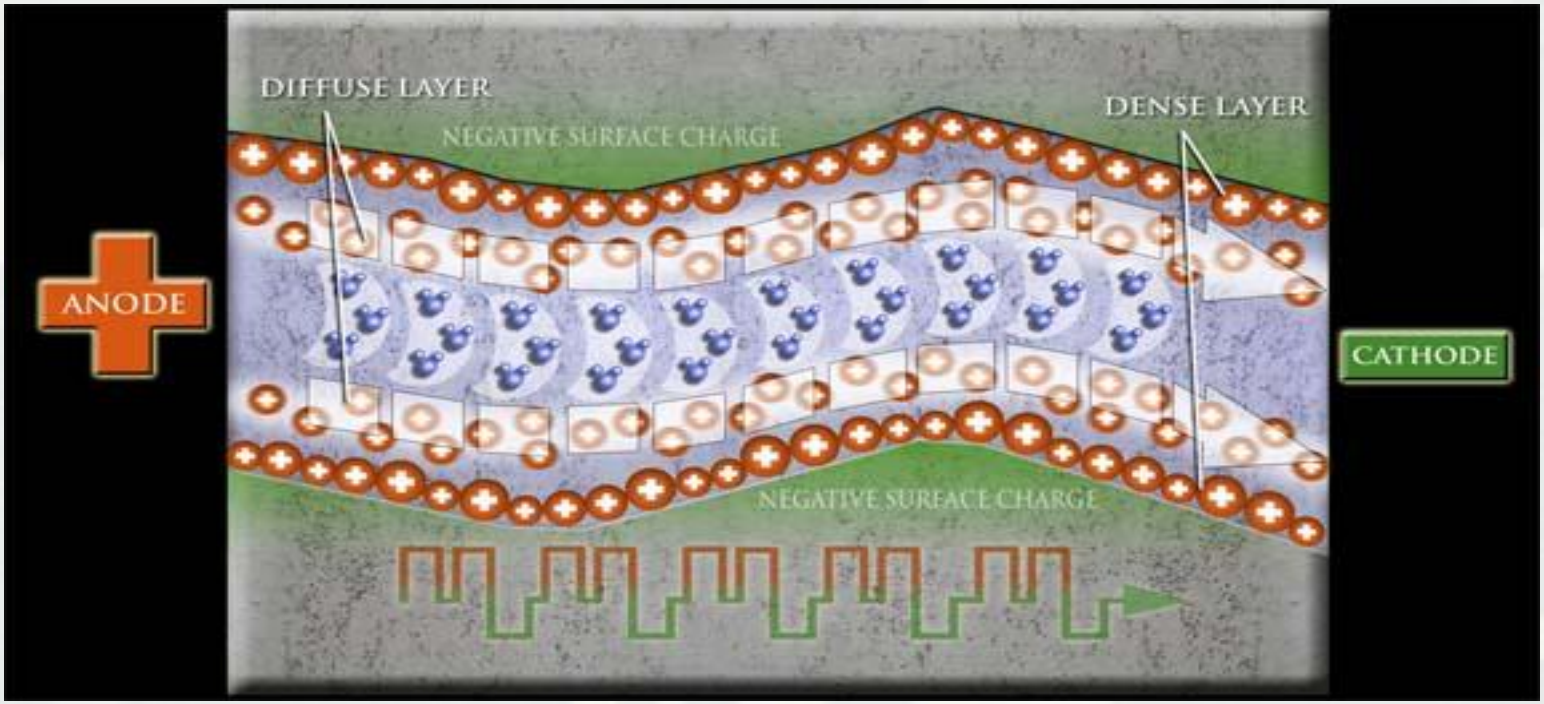
Background

ElectroOsmotic Pulse Technology For Prevention of Water Intrusion through Concrete



Underlying Principle

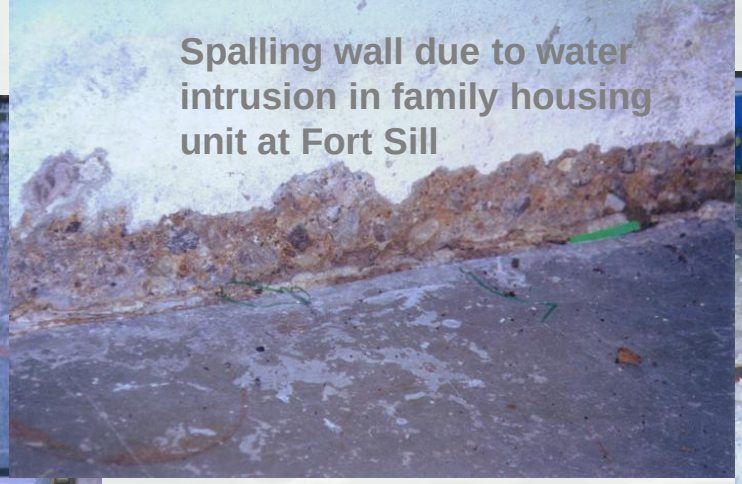
Electro-osmosis



The EO process occurs because of what is known as the double layer. The double layer refers to the layer of negative fixed surface charges of the pore and the cations in the pore solution. When an electrical gradient is applied, the cations migrate toward the cathode and the anions toward the anode. The double layer accounts for the fact that there must be more cations than anions to achieve neutrality and thus a net momentum will be imparted on the water molecules by cations and cause them also to migrate toward the cathode.

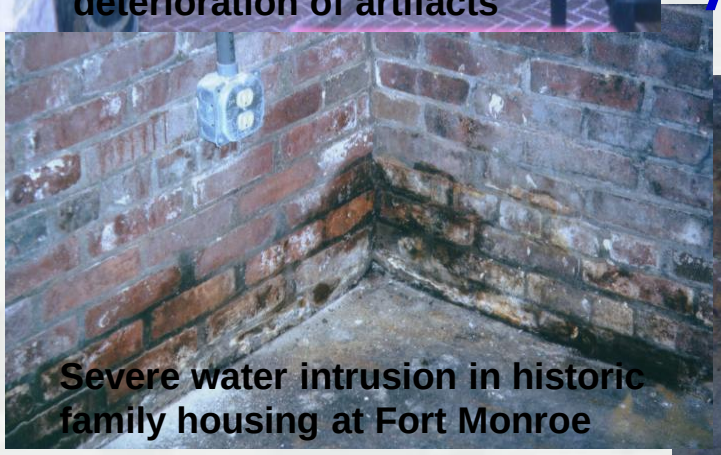
EOP Technology Demonstrations at Army Installations

Water intrusion in historic museums hastens deterioration of artifacts



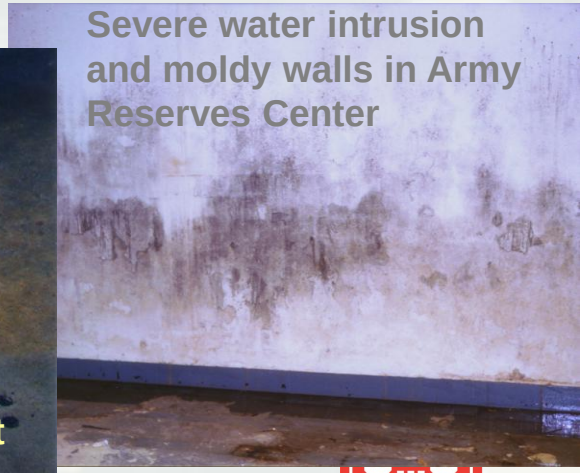
Spalling wall due to water intrusion in family housing unit at Fort Sill

Severe water damage in arms vault at Seivers-Sandburg Army Reserves Center



Severe water intrusion in historic family housing at Fort Monroe

Rusting support column in basement of historic housing at Fort Sill



Severe water intrusion and moldy walls in Army Reserves Center

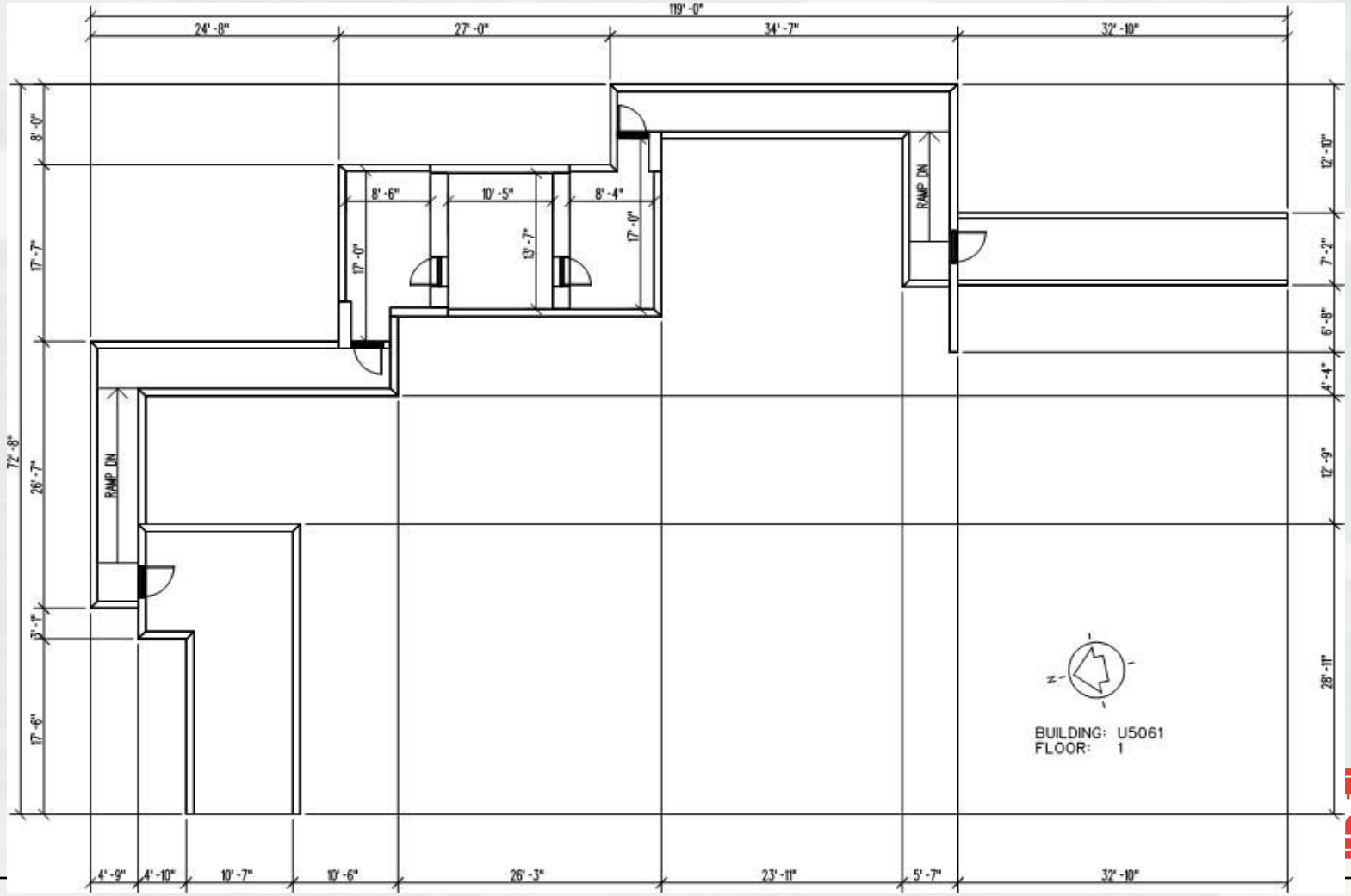
Test Site

Emperor Hirohito Air Raid Bunker

- National historic site
- The structure itself cannot be altered
- Any remedial action taken to reduce the moisture and damage to the structure must not alter the structure
- The typical “thru the wall” EOP system cannot be used
- New EOP-assisted dewatering wells will be used

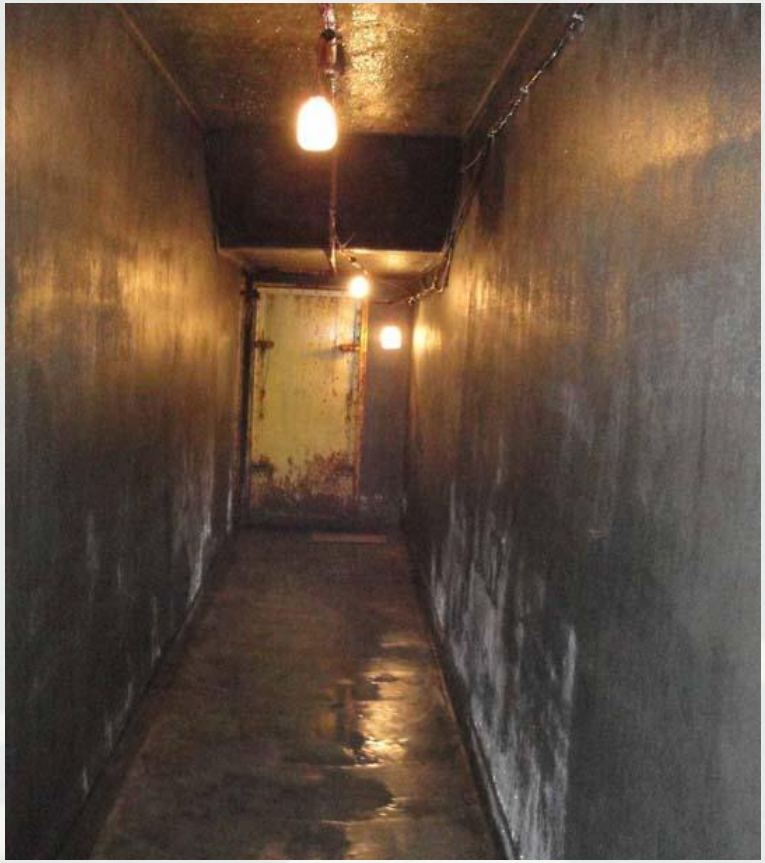
Front Exit on South side

Emperor Hirohito Air Raid Bunker Layout



Moisture Problem

- Obvious moisture infiltration
- Efflorescence on walls from lime leached from concrete
- Metal fittings rusted
- Over head piping and electric fixtures corroded



Lower Tunnel North Side

North Chamber Door

Top of Bunker North Side Entry

Top of Bunker Overhead

Technical Approach

- Demonstration site will use new technology developed and patented at ERDC
- New technology is a EOP-assisted dewatering well
- Stands off from actual building and does not require that the structure be modified
- Units work as individual “smart” ground water collection points
- No electrodes are installed in the building
- No holes are cut through the walls as would be done for the typical EOP dewatering system

US007135102B2

(12) **United States Patent**
Morefield et al.

(10) **Patent No.: US 7,135,102 B2**
(45) **Date of Patent: Nov. 14, 2006**

(54) **METHOD AND SYSTEM FOR DEWATERING PARTICULATE MATERIALS**

(75) Inventors: **Sean W. Morefield**, Champaign, IL (US); **Charles A. Weiss, Jr.**, Clinton, MS (US); **Philip G. Malone**, Vicksburg, MS (US); **Vincent F. Hock**, Mahomet, IL (US); **Michael K. McInerney**, Champaign, IL (US)

(73) Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, DC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 539 days.

(21) Appl. No.: **10/421,922**

(22) Filed: **Apr. 24, 2003**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
C25B 11/00 (2006.01)
B01D 57/02 (2006.01)

(52) **U.S. Cl.** **204/515**; 204/516; 204/648

(58) **Field of Classification Search** 204/515, 204/516, 648
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,110,582 A 8/1978 Tabanou
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6,372,109 B1 4/2002 Bjerke et al.

* cited by examiner

Primary Examiner—Arun S. Phasge
(74) *Attorney, Agent, or Firm*—Scott A. Felder; Nicholas J. Landau

(57) **ABSTRACT**

A system and method for dewatering particulate materials employs an improved dewatering probe generally including a single non-conducting pipe having a plurality of holes or slots, an anode mounted on the pipe adjacent one end of the pipe, and a cathode mounted on the pipe adjacent the opposite end of the pipe. The pipe serves as both a sonde for mounting the anode and cathode and as a well for extracting water that collects around the outside of the pipe and flows into the interior of the pipe through the holes or slots via gravitational and electro-osmotic forces. A pump may be used to extract both collected water and accumulated electrolytic gases from the pipe's interior. In embodiments, an array of guide electrodes is mounted on the pipe in addition to the anode and the cathode in order to deflect the major current flow out into the body of surrounding particulate materials. The guide electrodes also facilitate rapid depolarization of the probe. An array of probes according to the present invention may be employed as a system to dewater a volume of particulate.

30 Claims, 3 Drawing Sheets

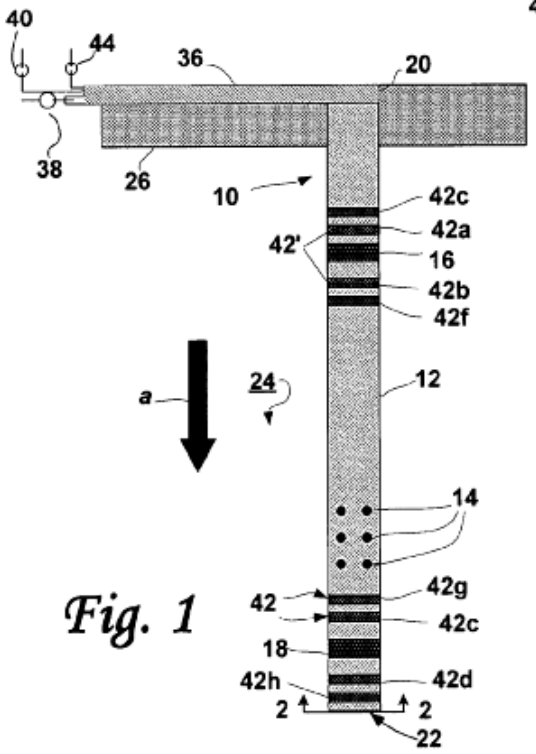
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Fig. 1

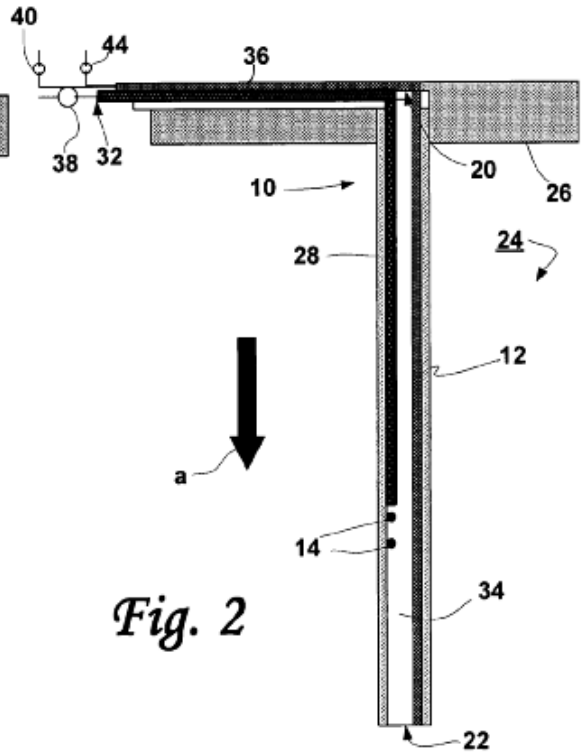
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Fig. 2

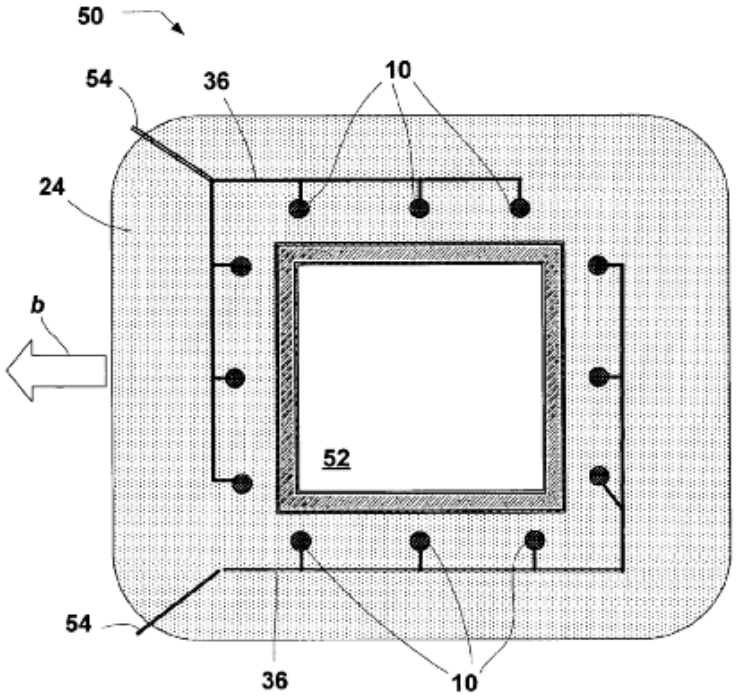

Fig. 3

US007135102B2

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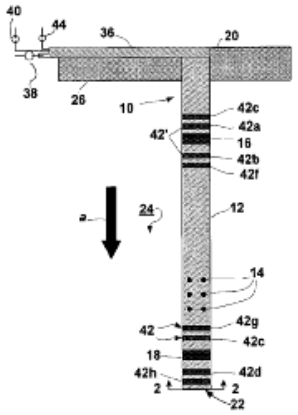
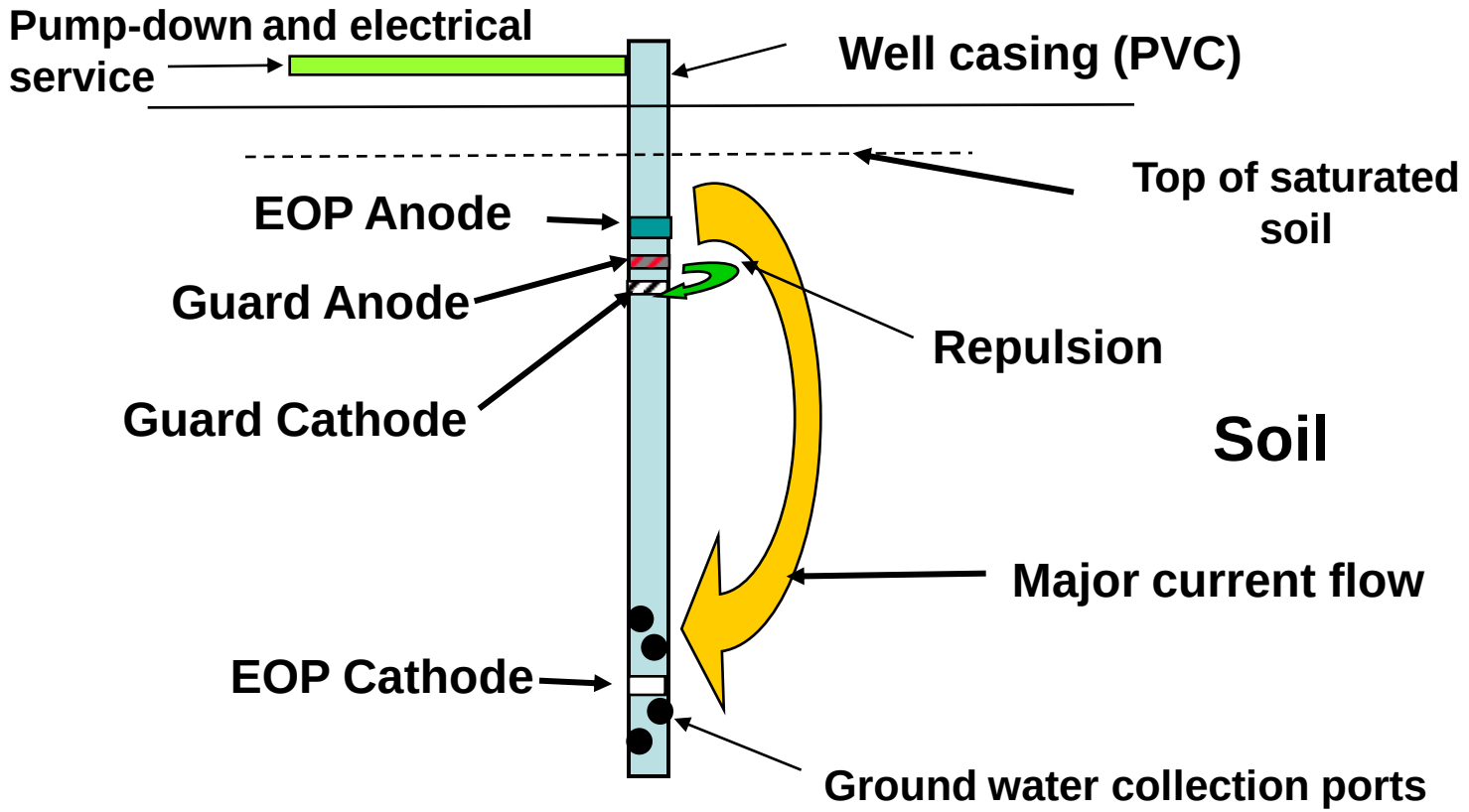


Technical Approach

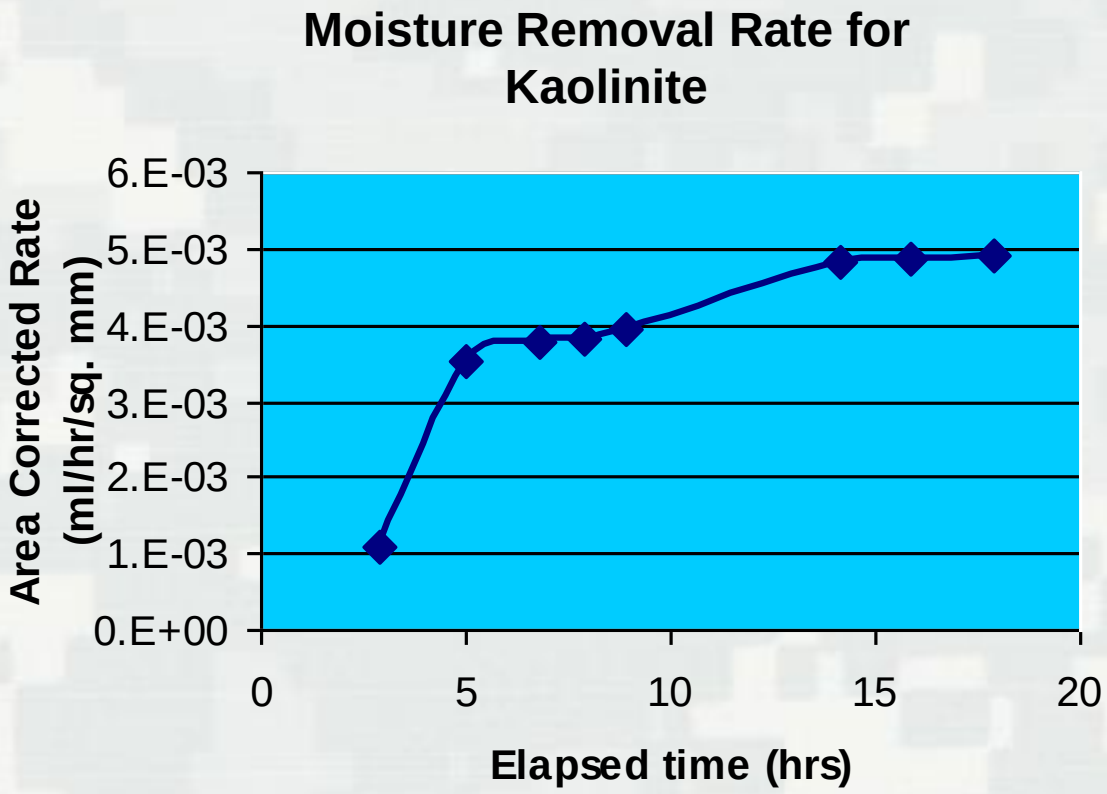
- **Major Design Factors Influencing Performance of EOP**
  - **Nature of soil on site**
    - **Type of clay minerals present**
    - **Ion exchange capacity of soil**
  - **Chemistry of soil water**
    - **Ionic strength (saline or freshwater)**
  - **Typical water content**
  - **Presence of hydraulic head at building-soil interface**
  - **Condition of building-soil interface with regard to transmission of moisture**

Schematic of EOP-Assisted De-watering Well



Laboratory Results

EOP Performance Envelope for Clay



- Can be installed inside or outside building
- Can be converted to “smart system” that senses and responds to moisture
- Clay barrier can be engineered to work with EOP as a “self-regulating” pump

Data Collection Program

- Operation of each extraction well
  - Time of operation
  - Power usage
  - DC voltage pattern used
  - Pumping pattern
- Depth to ground water from adjacent monitoring wells
- Condition inside target structure (Air Raid Bunker)

Summary

- Demonstration program will use a new EOP-assisted ground water extraction system
- New units will not involve an intrusion into the target structure
- EOP performance will be optimized for the site as data are collected

Discussions